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Household air pollution and lung function in Indian adults: a cross-sectional study

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Running head: indoor pollution and lung function

36 **Summary**

37 Exposure to air pollution produced by cooking is common in developing countries, and
38 represents a potentially avoidable cause of lung disease. Cross-sectional data were
39 collected by the WHO-SAGE study in India between 2007 and 2010. Exposure to biomass
40 cooking was also associated with a decrease in FEV₁ in one second (-70ml; 95% CI: -111
41 to -30) and FEV₁/FVC ratio (-0.025; 95% CI: -0.035 to -0.015) compared to those who
42 were not exposed. These associations were predominantly observed in males (p <0.05 for
43 interaction analyses). Intervention studies using non-biomass fuels in India are required to
44 ascertain potential respiratory health benefits.

46 **Background**

47 Three billion people around the world use dirty-burning fuels to provide energy for their
48 day-to-day cooking, heating and lighting needs ¹. Four million people die every year from
49 diseases caused by household air pollution from the burning of these fuels in or around
50 the home environment. The major adverse health effects attributed to household air
51 pollution are pneumonia in children and cardiovascular and chronic pulmonary diseases in
52 adults. The Global Burden of Disease Study estimated that household air pollution is the
53 second highest risk factor for the total burden of disease in India. However, there are few
54 population-based studies of the association between exposure to household air pollution
55 and lung function in India. There is a particular need for information about household air
56 pollution and the risk of chronic lung disease in rural India which is where 68% of the 1.3
57 billion population live and most are dependent on the use of biomass fuels for cooking ².

59 **Methods**

60 We used cross-sectional data that were collected from India as part of the World Health
61 Organization's Study on Global Ageing and Adult Health (WHO-SAGE ³) to test the
62 hypotheses that exposures to biomass fuel, poor ventilation or cooking in a communal
63 living space are associated with decreased lung function. Data were used from 'Wave 1'
64 collected in India by 2007 ^{4,5}. Briefly, study participants were randomly selected and data
65 were collected on a range of health and well-being indicators at both individual and
66 household levels, from adults aged ≥18 years. Forced Expiratory Volume in one second
67 (FEV₁) and Forced Vital Capacity (FVC) were measured using a Medical International
68 Research SpiroDoc Diagnostic Portable Spirometer. Measurements were taken with the
69 participant sitting down, and after one trial involving maximal inhalation and exhalation,
70 three lung function measurements were recorded, and the highest value selected for

71 analysis. Linear regression was used to investigate the associations adjusting for potential
72 confounding factors using robust standard errors to allow for clustering by household
73 using Stata Statistical software (v13.1, Texas, USA). The study received approval from an
74 Ethics Committee and all participants gave informed consent.

75

76 **Results**

77 The response rate was 92% for the individual questionnaires and 88% for the household
78 level questionnaires. Of the 12128 individuals surveyed, 7639 (63%) provided lung
79 function data for analysis (Table). The population is predominantly rural (74%), and female
80 (61%), with the commonest cooking fuels being wood (58%) and gas (25%). 12% of the
81 population cooked in the living space and 82% had no hood or chimney to vent emissions.

82

83 The use of biomass fuels (Table 1) was associated with a decrease in FEV₁ in one second
84 (-70ml; 95% CI: -111 to -30) and FEV₁/FVC ratio (-0.025; 95% CI: -0.035 to -0.015)
85 compared to those who used electricity or gas. This association was predominantly
86 observed in males (p <0.05 for interaction for both analyses). There was no association
87 between the use of biomass fuels and FVC. There was no association between the
88 presence of ventilation or cooking in the living space with lung function.

89

90 **Discussion**

91 This large study conducted in six Indian States found that exposure to biomass fuel is
92 associated with a decrease in lung function with an obstructive pattern that is larger in
93 males than females. These data are broadly consistent with another study from
94 Maharashtra State, India, which reported the association between cooking fuels and
95 respiratory health in 1156 individuals ⁶. In this study a higher risk of respiratory symptoms
96 was observed in females who used agro-waste compared to baseline, and lower FEV₁ and
97 FVC in women who lived in houses that used agro-waste and wood, and men who lived in
98 wood-using houses. A study of 760 non-smoking women from Maharashtra State reported
99 higher prevalences of chronic bronchitis and lower peak expiratory flow rates in those who
100 cooked using biomass fuels compared to those who did not ⁷.

101

102 Data from outside India are consistent with our data. In rural women who live in Mexico,
103 the use of biomass fuels was associated with increased rates of phlegm production and
104 reduced FEV₁/FVC ratio compared with gas cooking ⁸. An intervention study in Guatemala
105 used chimney woodstoves, and reported a decrease in wheeze and respiratory symptoms,

106 but not lung function after 18 months ⁹. The introduction of a biomass stove intervention in
107 rural Mexico was associated with fewer respiratory symptoms and lower decline in lung
108 function over the following year ¹⁰.

109

110 The strengths of our data are the systematic data collection with lung function from a
111 relatively large population of adults in six Indian States. The high proportion of individuals
112 who live in a rural community is informative, as these constitute a difficult to reach
113 population, who represent those most at risk from air pollution secondary to cooking. The
114 limitations of these data include the availability of lung function data in 63% of the sample,
115 and hence we are unable to exclude the possibility of self-selection bias such as females
116 with worse lung function not providing data. However, with the exception of a higher
117 number of females who provided lung function data compared to males, the population of
118 those who provided lung function data was similar to those who did not. We did not have
119 validated reference values of lung function in this heterogenous population, and the high
120 prevalence of exposure to biomass fuels would make definition and interpretation of
121 normal values challenging. In addition, the impact of biomass fuels on respiratory health
122 will vary across populations as the composition of biomass fuels can be expected to vary
123 according to location, as may the susceptibility of both individuals and hence populations
124 to air pollution.

125

126 In conclusion, these data demonstrate an association between the use of biomass fuels
127 and decreased lung function with an obstructive pattern. The association is greater in
128 men, which was surprising, as in Indian culture the cooking is generally done by women
129 suggesting that other lifestyle factors associated with biomass cooking may also be
130 important. This requires closer observation using prospective studies of change in lung
131 function in similar populations.

132

133 **Acknowledgements**

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135 data. AF, AA, PM and MD generated the hypothesis and analysed the data. KM provided
136 critical appraisal of the analysis. All authors contributed to the drafting of the manuscript.

137

Table 1. Association between cooking fuel, ventilation and location with lung function

<u>Descriptive variables</u>	<u>No lung function data</u> N=4489	<u>Lung function data available</u> N=7639	
Number of Males (%)	1512 (34)	3167 (41)	
Mean age (years)	50.9 (17.8)	49.4 (16.1)	
State of residence (%)			
Assam	387 (9)	802 (10)	
Karnataka	790 (18)	954 (12)	
Maharashtra	912 (20)	1303 (17)	
Rajasthan	784 (17)	1590 (21)	
Uttar Pradesh	814 (18)	1577 (21)	
West Bengal	802 (18)	1413 (18)	
Rural area of residence	3345 (75)	5651 (74)	
Height, m (sd)	1.54 (0.10) N=3298	1.57 (0.09) N=7620	
FEV₁, L, (sd)	-	1.57 (0.75)	
FVC, L, (sd)	-	2.16 (1.08)	
FEV₁/FVC	-	0.75 (0.18)	
Ever used tobacco, %	1416 (40) N=3521	2370 (43) N=7638	
Main cooking fuel	N=4486	N=7637	
Gas	1047 (23)	1937 (25)	
Electricity	5 (0.1)	6 (0.1)	
Kerosene/paraffin	43 (1)	94 (1)	
Coal/charcoal	89 (2)	188 (2)	
Wood	2653 (59)	4340 (57)	
Agricultural residue	348 (8)	552 (7)	
Animal dung	348 (5)	402 (5)	
Shrubs, grass	231 (1)	113 (1)	
Other	3 (0.1)	5 (0.1)	
<u>Association of exposure to air pollution with lung function</u>			
	<u>Biomass fuel* for cooking</u> (95% CI)	<u>No chimney/hood</u> (95% CI)	<u>Cooking in living space</u> (95% CI)
<u>No. exposed (%)</u>	5689 (75)	4669 (83)	631 (11)
<u>FEV₁ (ml)</u>			
All	-70 (-111 to -30)	-19 (-76 to +37)	+33 (-30 to +97)
Males	-145 (-210 to -79)**	-43 (-136 to +49)	+39 (-64 to +141)
Females	-13 (-63 to +37)	-6 (-73 to +61)	+34 (-42 to +111)
<u>FVC (ml)</u>			
All	-10 (-70 to +49)	+7 (-86 to +100)	+38 (-55 to +130)
Males	-56 (-138 to +26)	-71 (-201 to +58)	+12 (-125 to +150)
Females	+29 (-50 to +107)	+62 (-64 to +189)	+56 (-68 to +179)
<u>FEV₁:FVC</u>			
All	-0.025 (-0.035 to -0.015)	-0.007 (-0.023 to +0.008)	-0.001 (-0.017 to +0.014)
Males	-0.038 (-0.053 to -0.024)**	+0.004 (-0.016 to +0.025)	+0.001 (-0.023 to +0.024)
Females	-0.015 (-0.029 to -0.002)**	-0.016 (-0.038 to +0.005)	-0.001 (-0.022 to +0.021)

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Bold = p <0.05

* Biomass fuel defined as all fuel except gas and electricity.

** p < 0.05 for interaction between sex and exposure.

CI = confidence intervals

Biomass fuels compared with gas and electricity as reference group.

Linear regression model beta co-efficients adjusted for age in categories, sex, Indian State of residence, height and tobacco usage with robust standard errors used to allow for clustering by household

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